

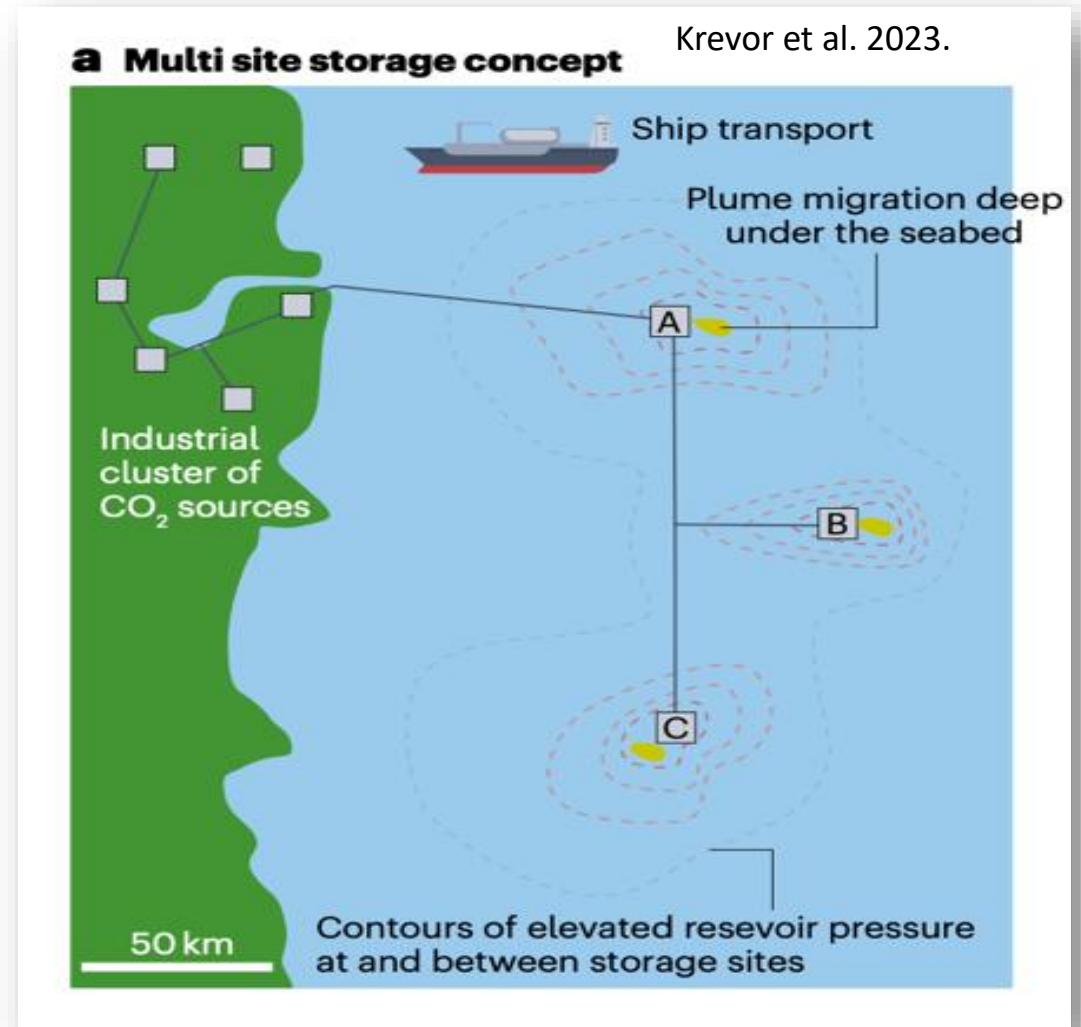
Modelling strategies for managing pressure interference in multi-site CO₂ storage in large regional aquifers

Tor Harald Sandve, David Landa-Marbán, Sarah Gasda

FORCE SEMINAR 14. OCTOBER 2025

Managing pressure

- CO₂ Injection vs. hydrocarbon extraction.
- Common pressure resource
- Multiple actors

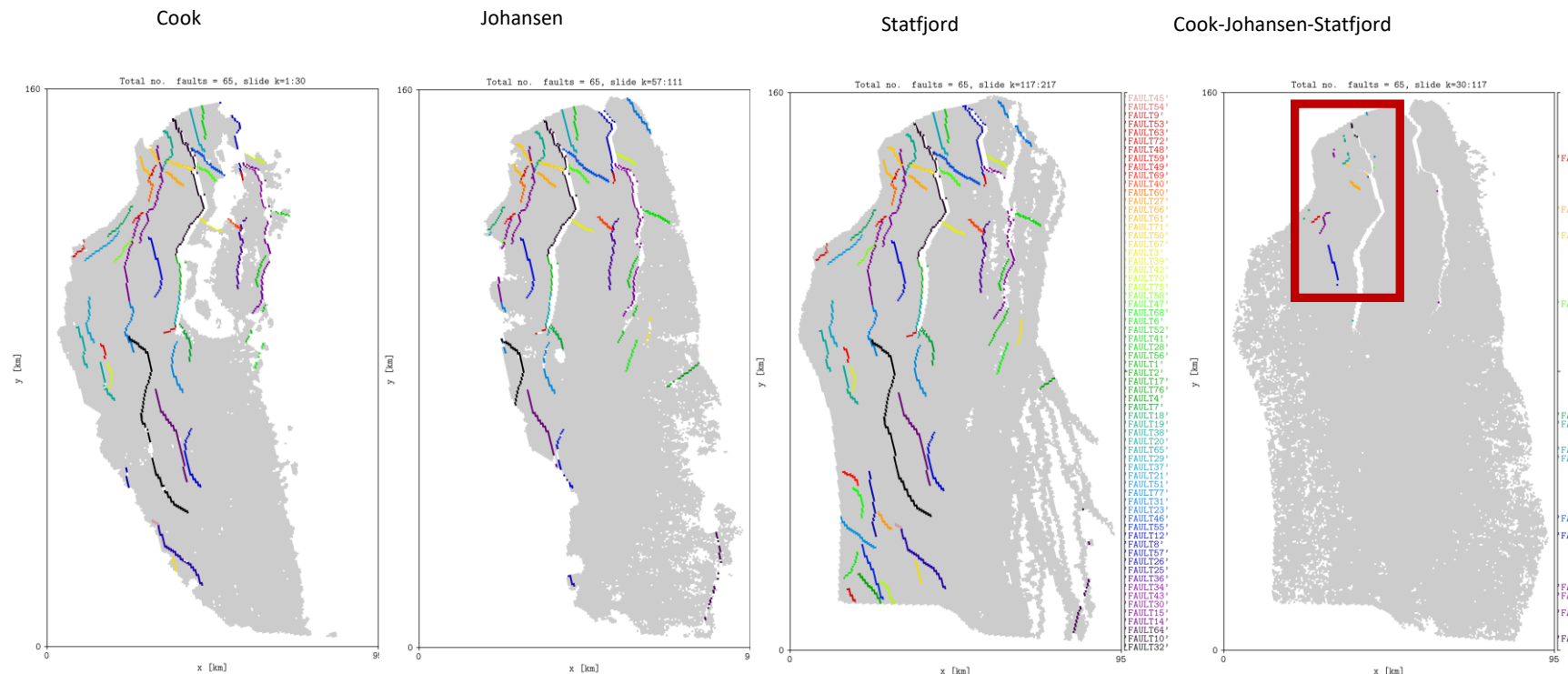
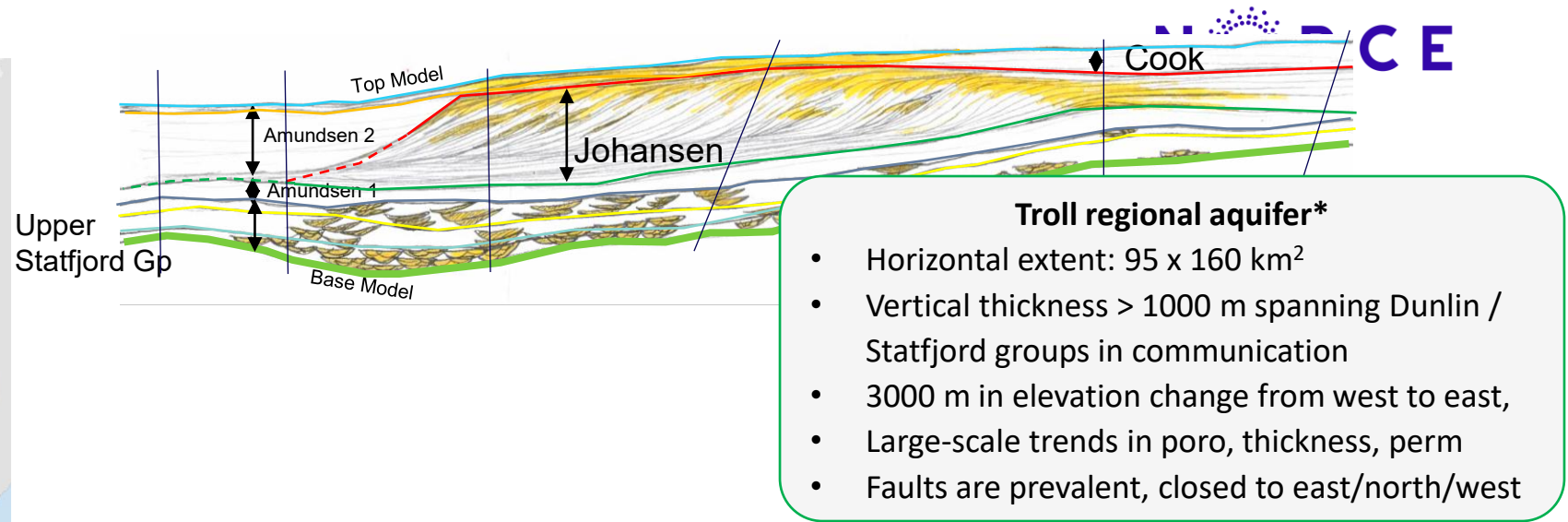
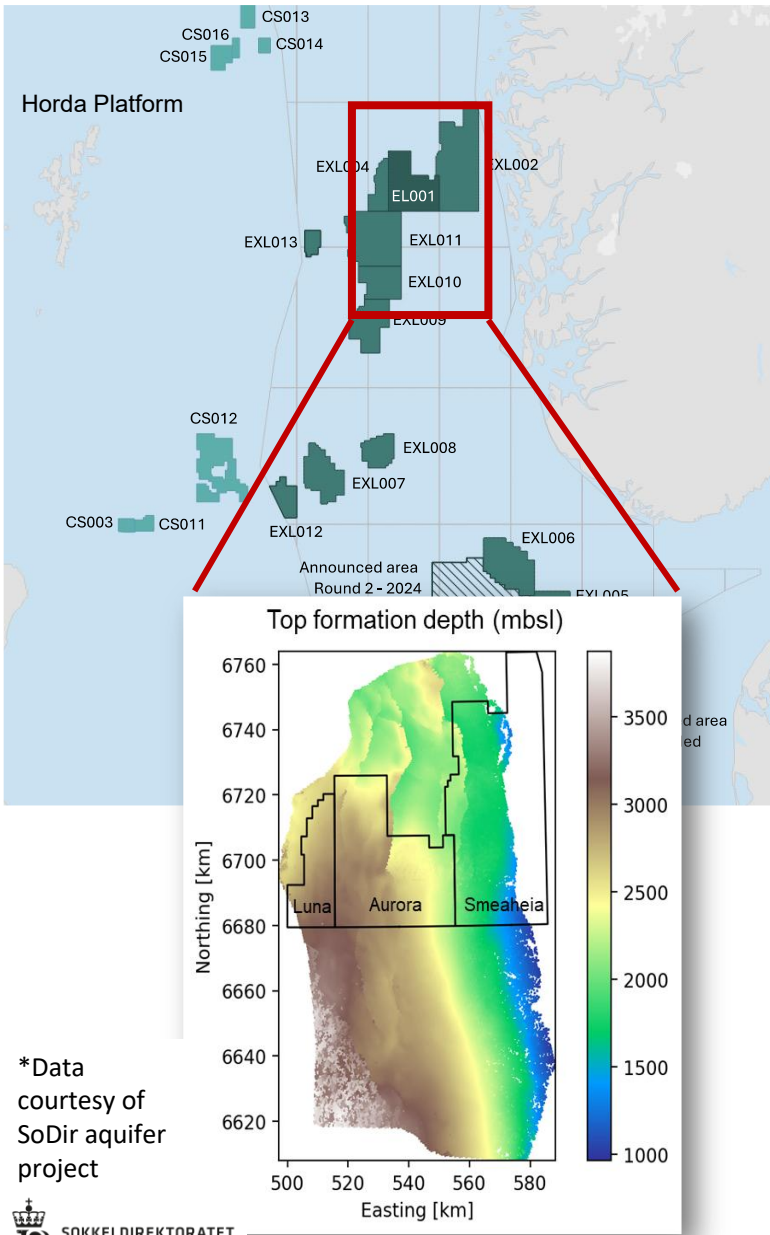


Overview: regional modeling

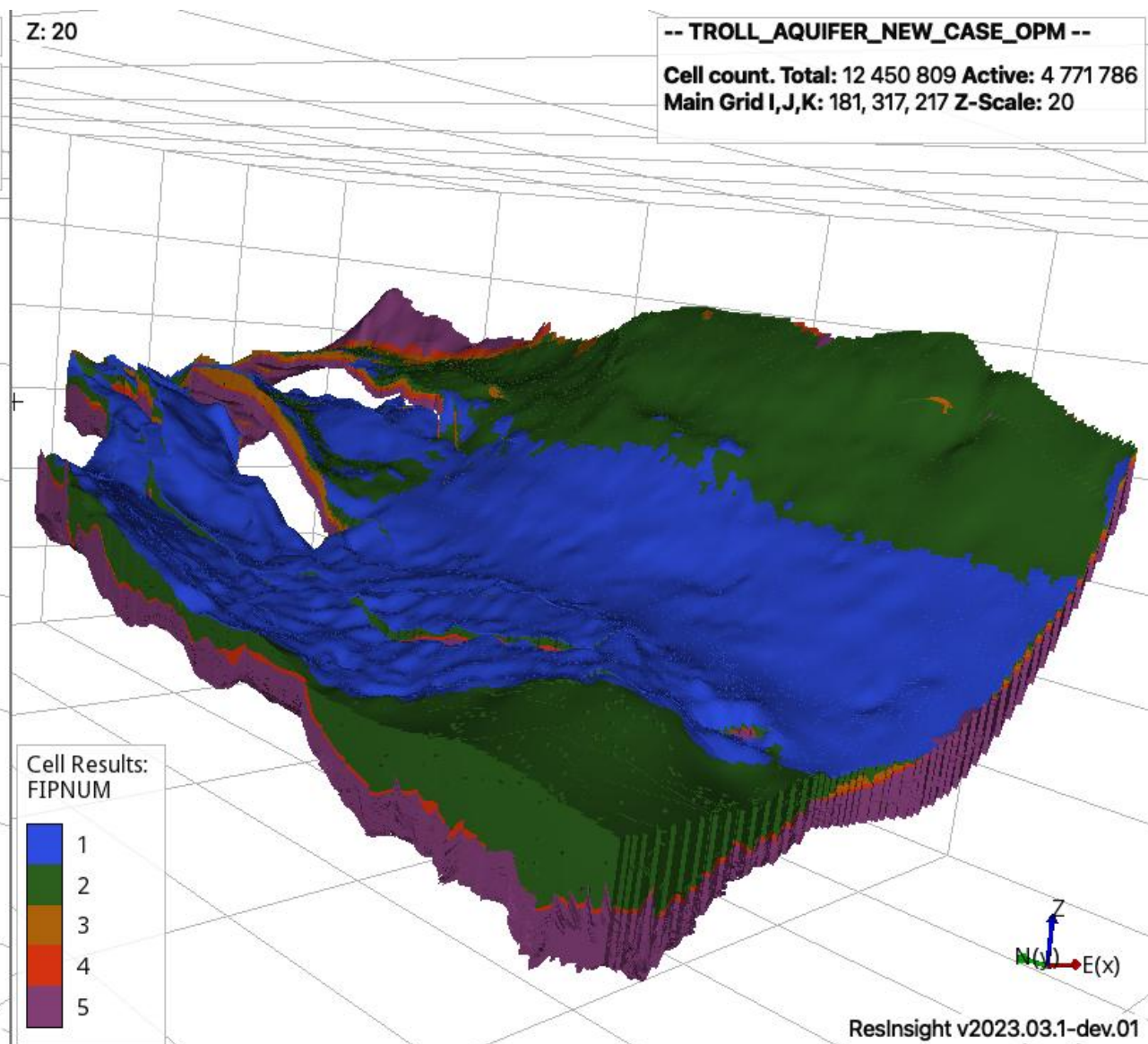
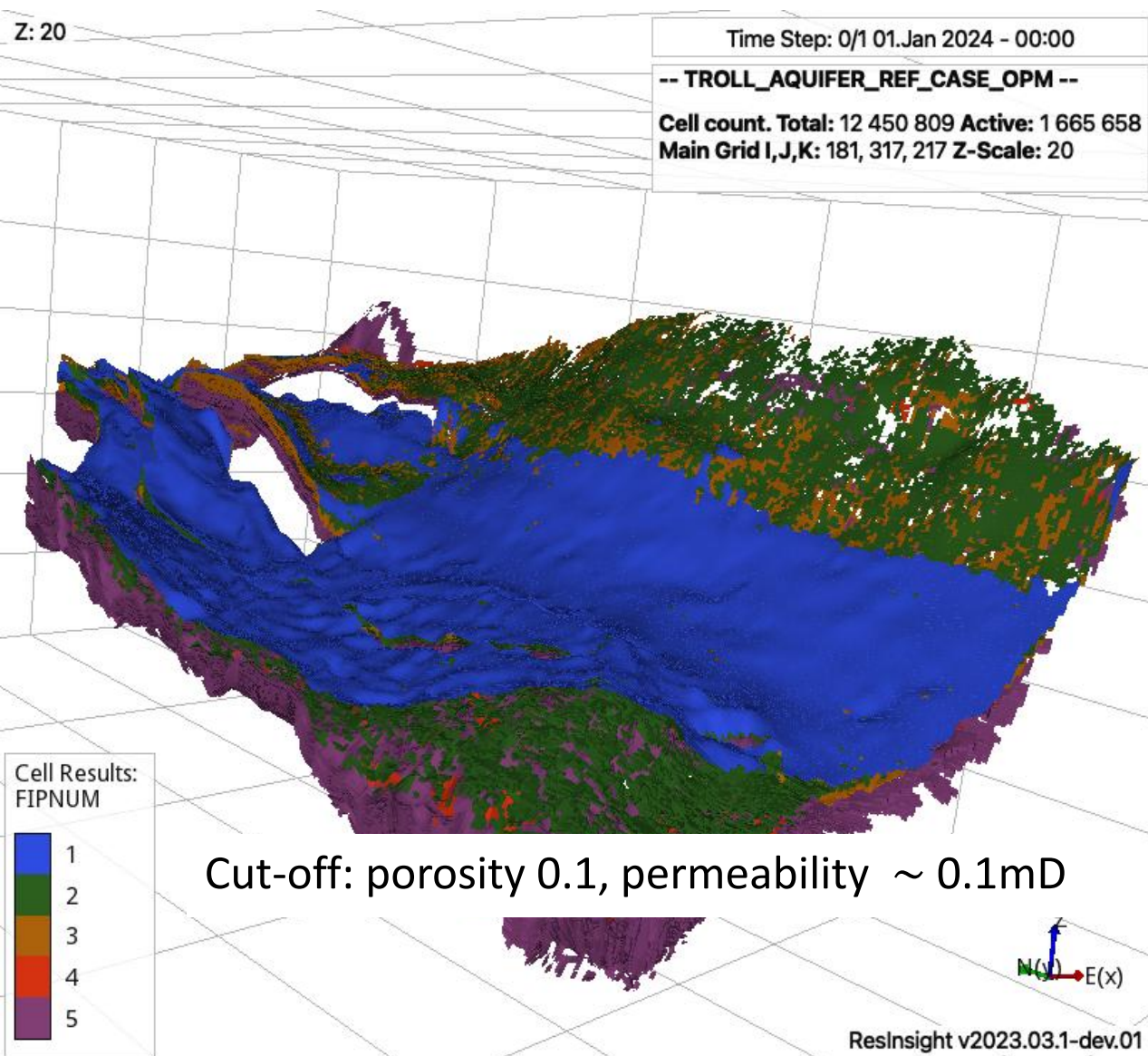


1. Impact of “non-net” portion of the reservoir on the long-term regional pressure
 2. Grid resolution for regional models - Grid coarsening
 3. Multi-site coupling - A hierarchical approach
- Demonstrated on the Troll regional model from SoDir.

Troll regional aquifer



Filling the gaps (non-net cells)



Pressure after 25 years (end of injection)

PERM:

1E-8 mD

1E-7 mD

1E-6 mD

1E-5 mD

1E-4 mD

1E-3 mD

1E-2 mD

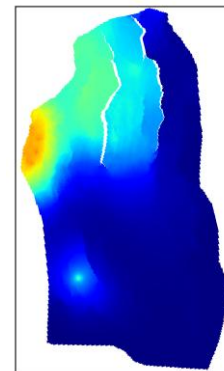
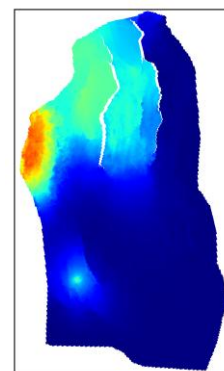
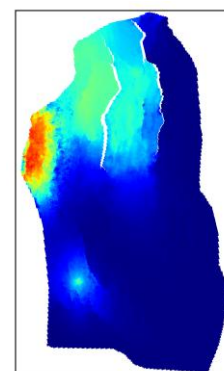
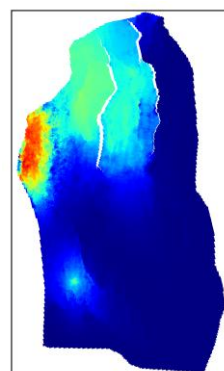
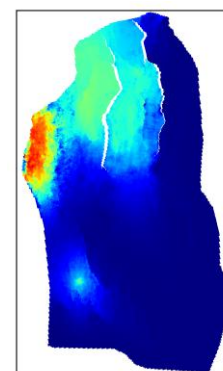
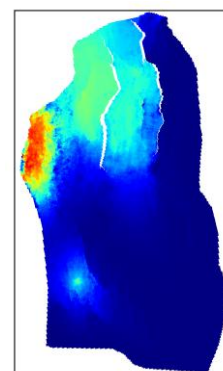
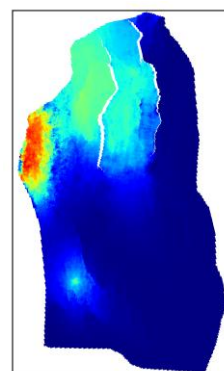
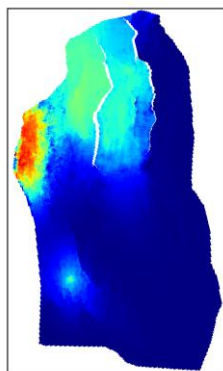
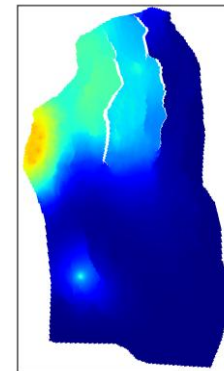
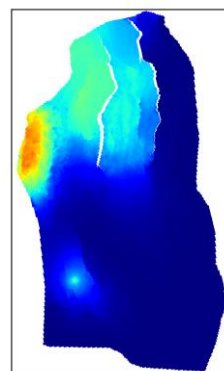
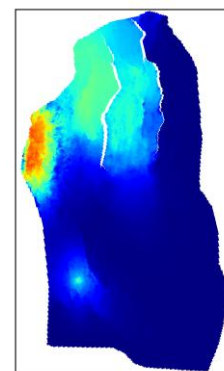
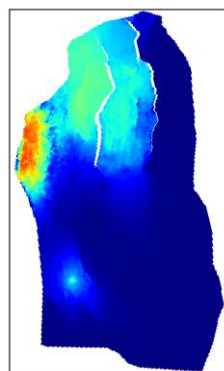
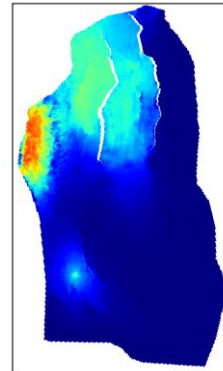
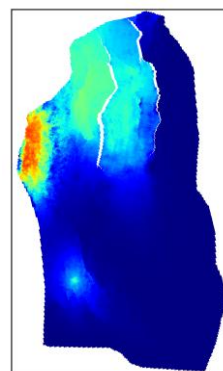
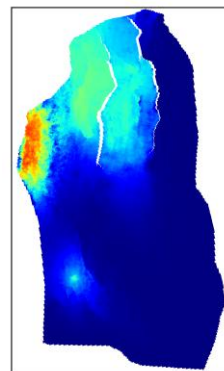
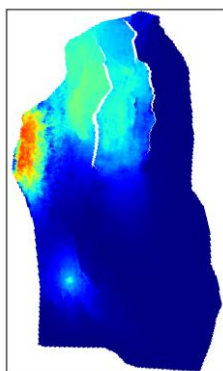
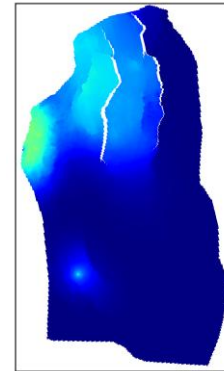
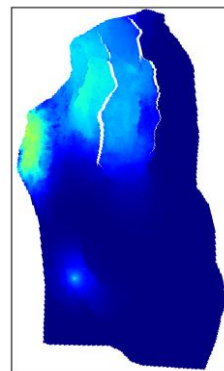
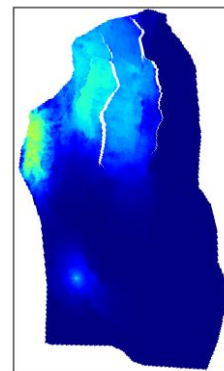
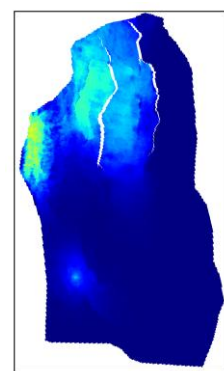
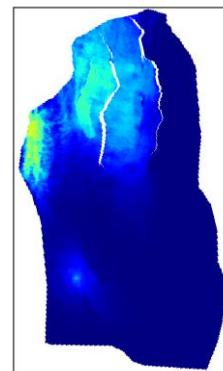
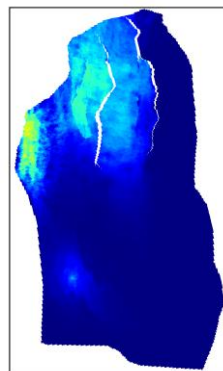
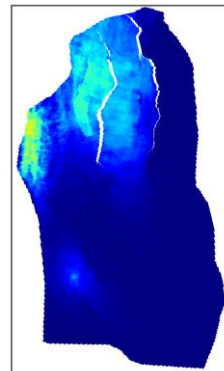
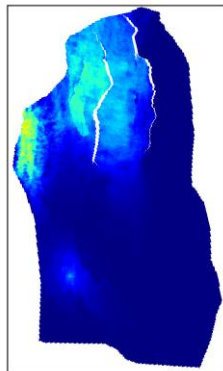
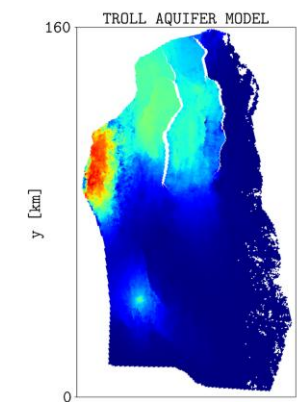
1E-1 mD

PORO: 0.1

PORO: 0.01

PORO: 0.001

25 years, pressure increase [bar]
0.0 22.9 45.7 68.6 91.5



Pressure after 125 years

PERM:

1E-8 mD

1E-7 mD

1E-6 mD

1E-5 mD

1E-4 mD

1E-3 mD

1E-2 mD

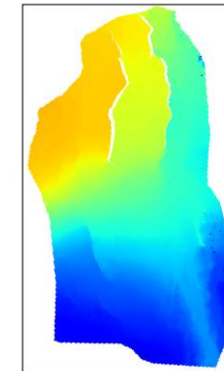
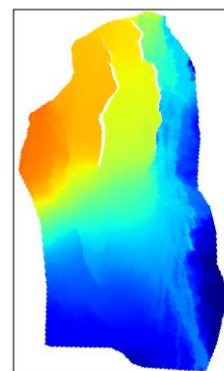
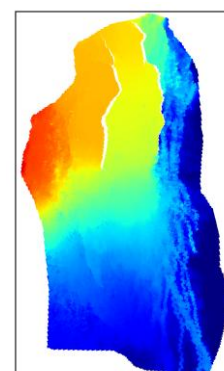
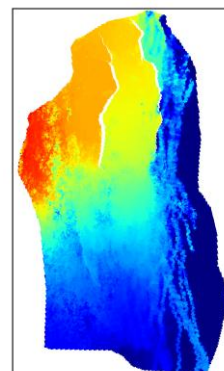
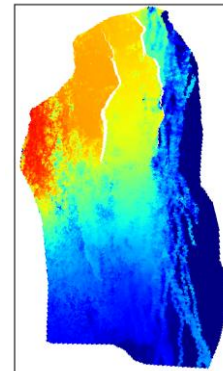
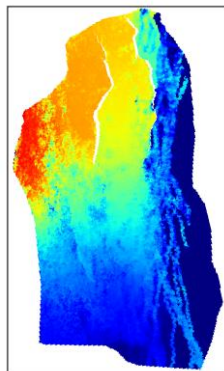
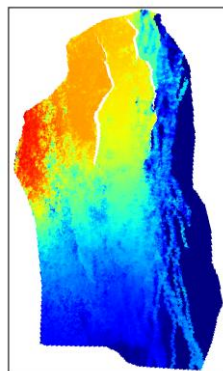
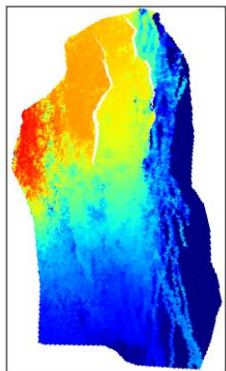
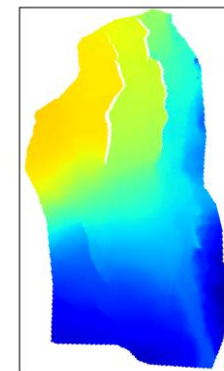
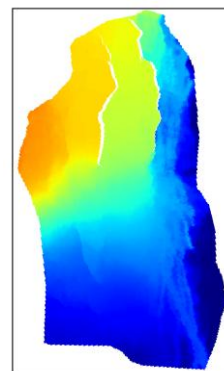
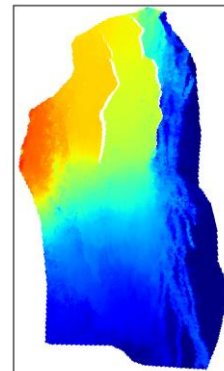
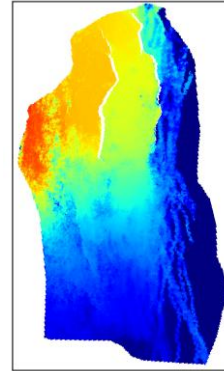
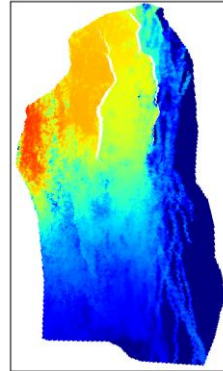
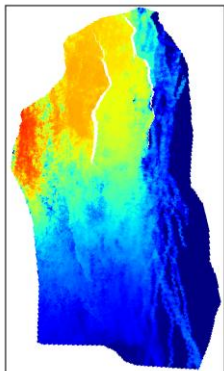
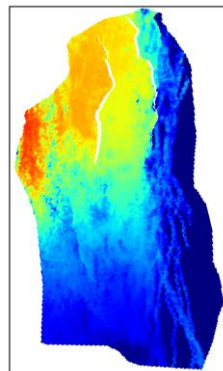
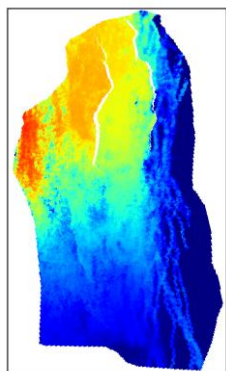
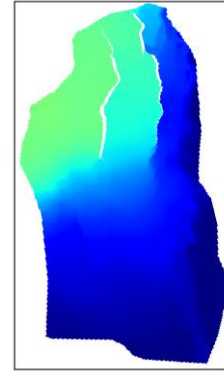
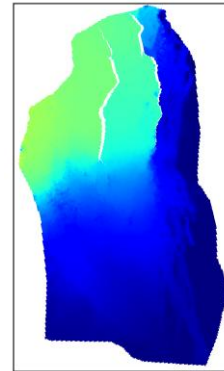
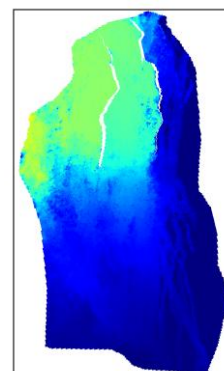
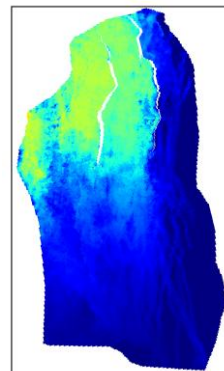
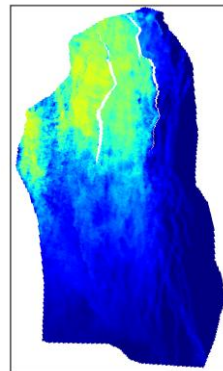
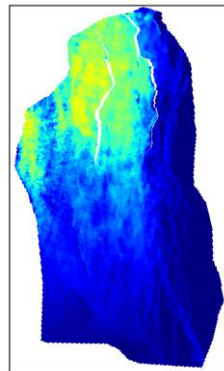
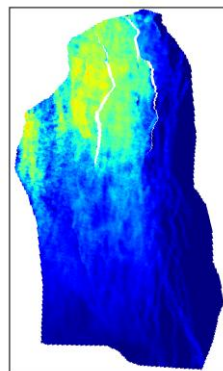
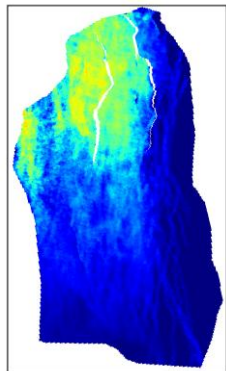
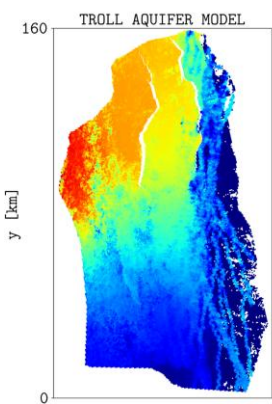
1E-1 mD

PORO: 0.1

PORO: 0.01

PORO: 0.001

125 years, pressure increase [bar]
0.0 11.5 22.9 34.4 45.8



Pressure after 525 years

PERM: 1E-8 mD

1E-7 mD

1E-6 mD

1E-5 mD

1E-4 mD

1E-3 mD

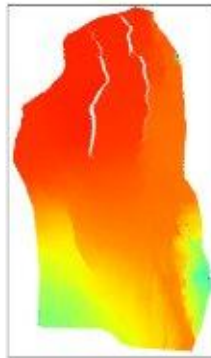
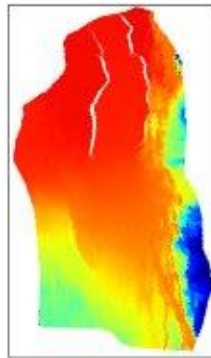
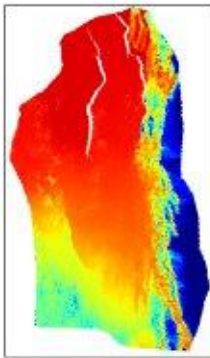
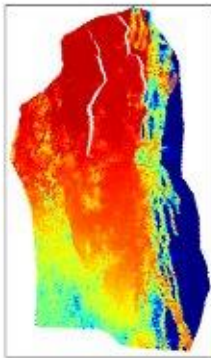
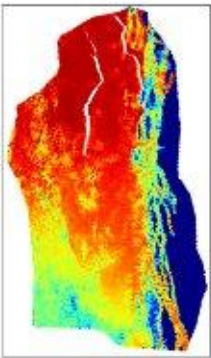
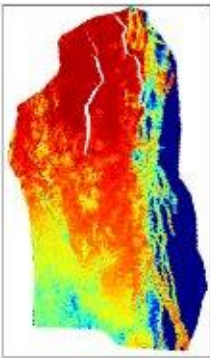
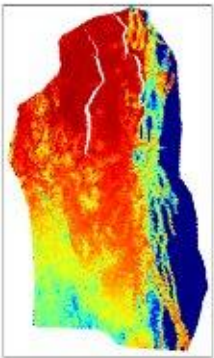
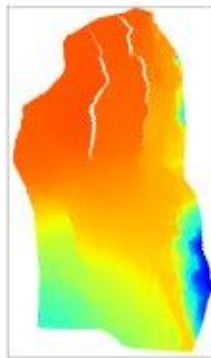
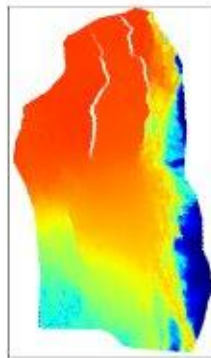
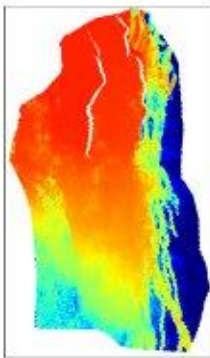
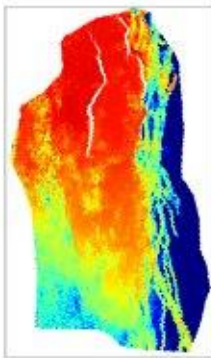
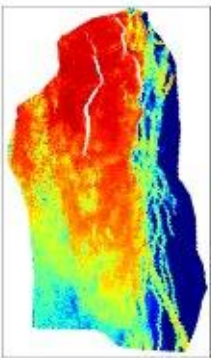
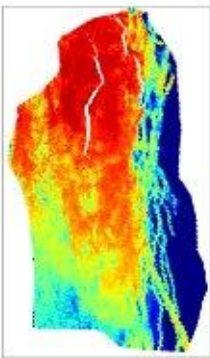
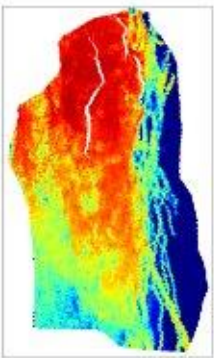
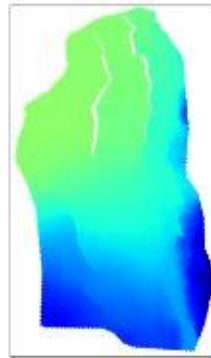
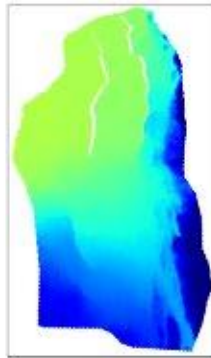
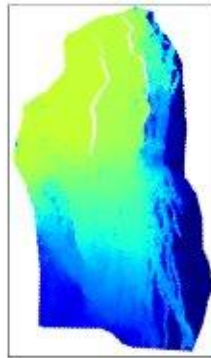
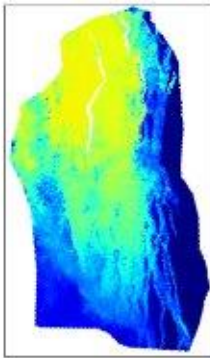
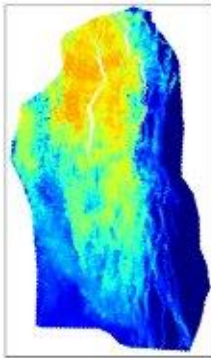
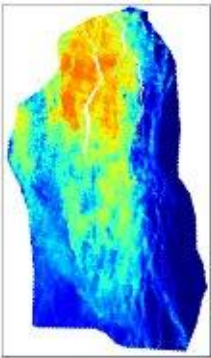
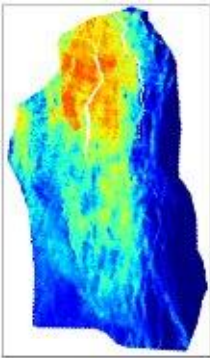
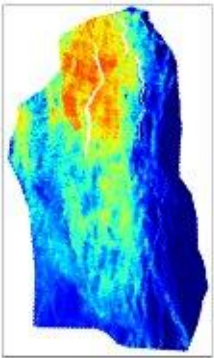
1E-2 mD

1E-1 mD

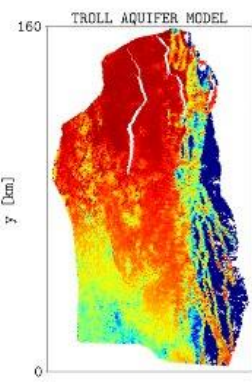
PORO: 0.1

PORO: 0.01

PORO: 0.001



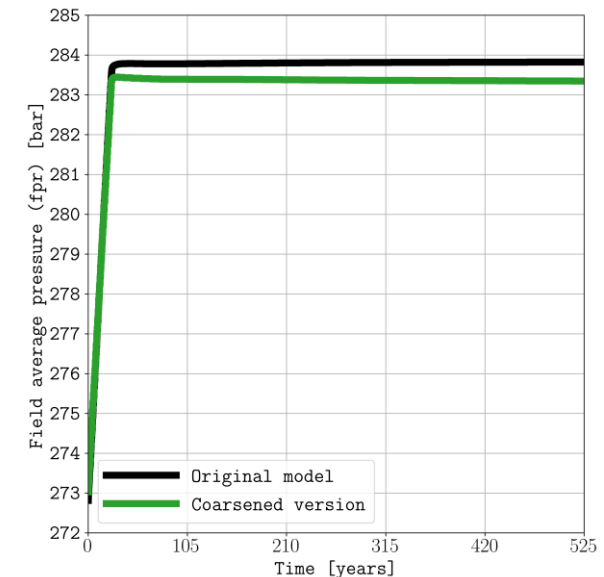
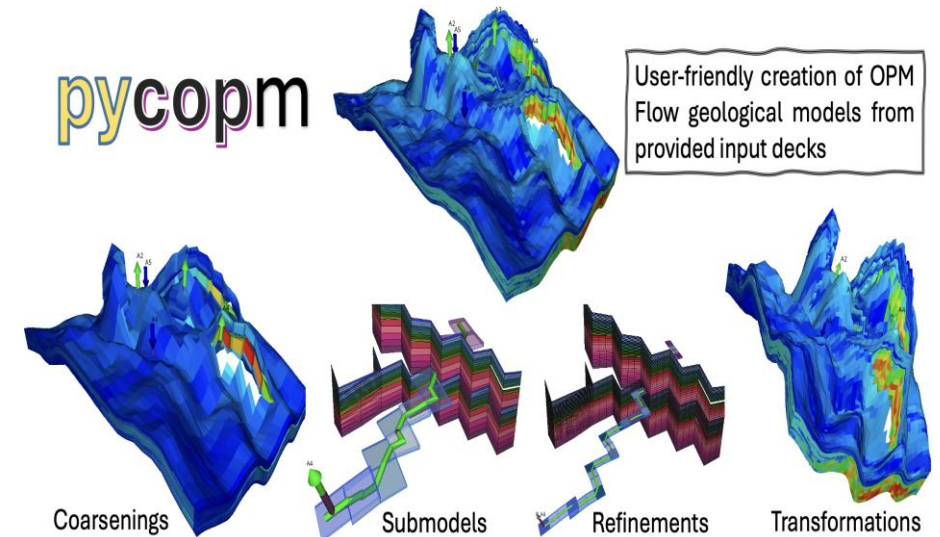
525 years, pressure increase [bar]
0.00 7.25 14.50 21.75 29.00



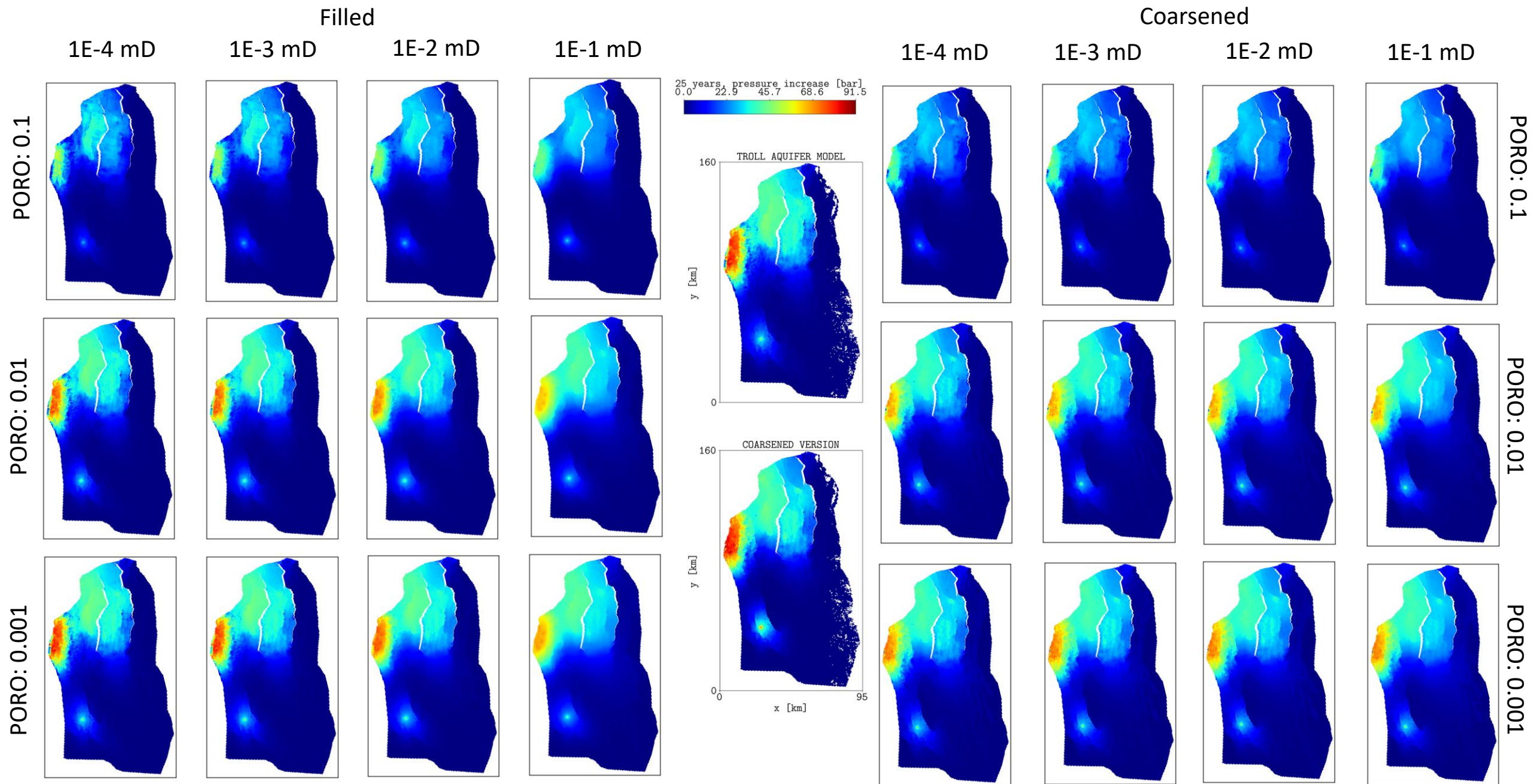
Coarsening



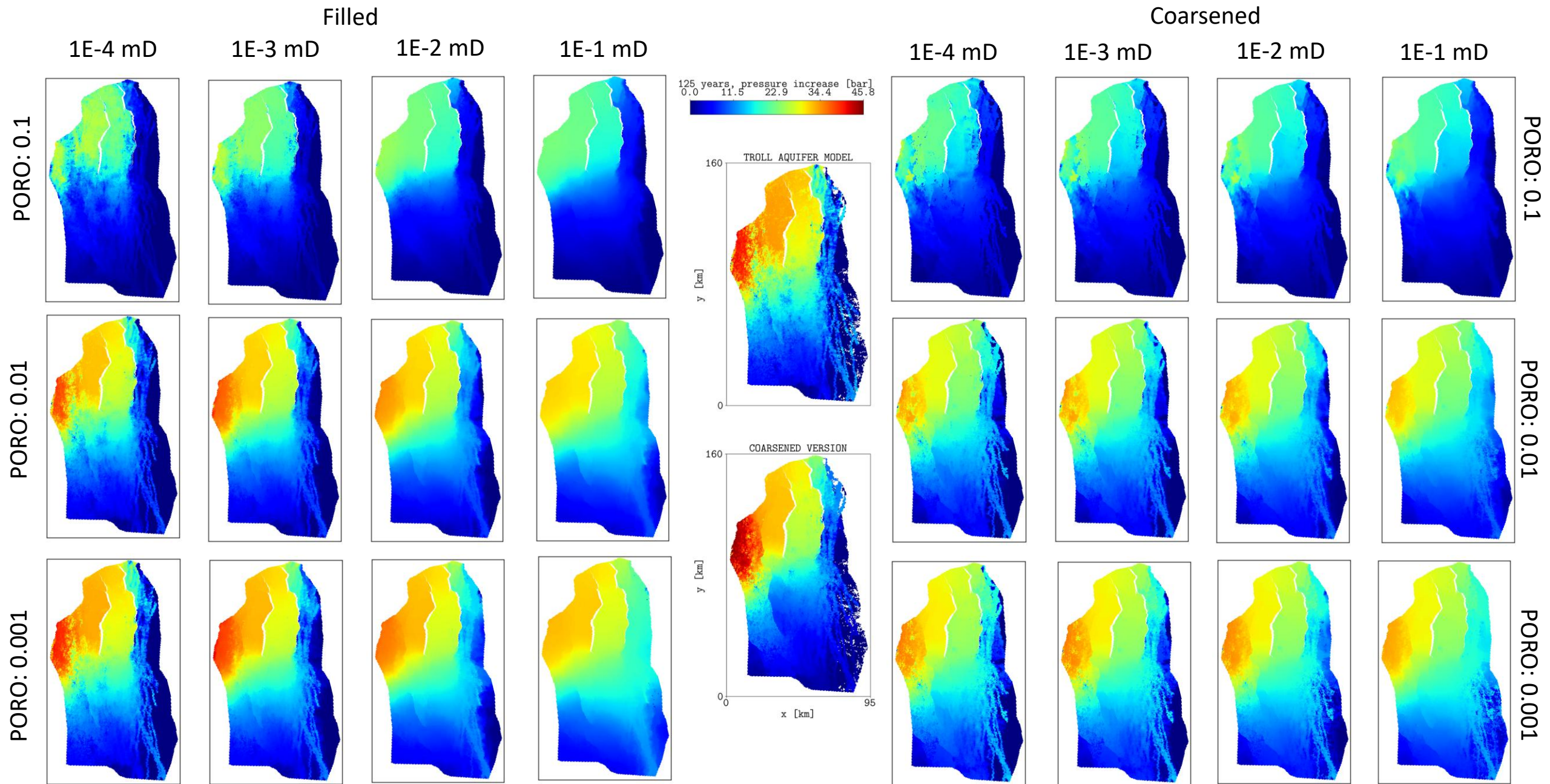
- Coarse cells in z-direction -> one layer per formation
- Upscale transmissibility and pore volumes
- Open-source tool: pycopm
- “A Coarsening Approach to the Troll Aquifer Model” TCCS 13-2025
(<https://arxiv.org/abs/2508.08670>)



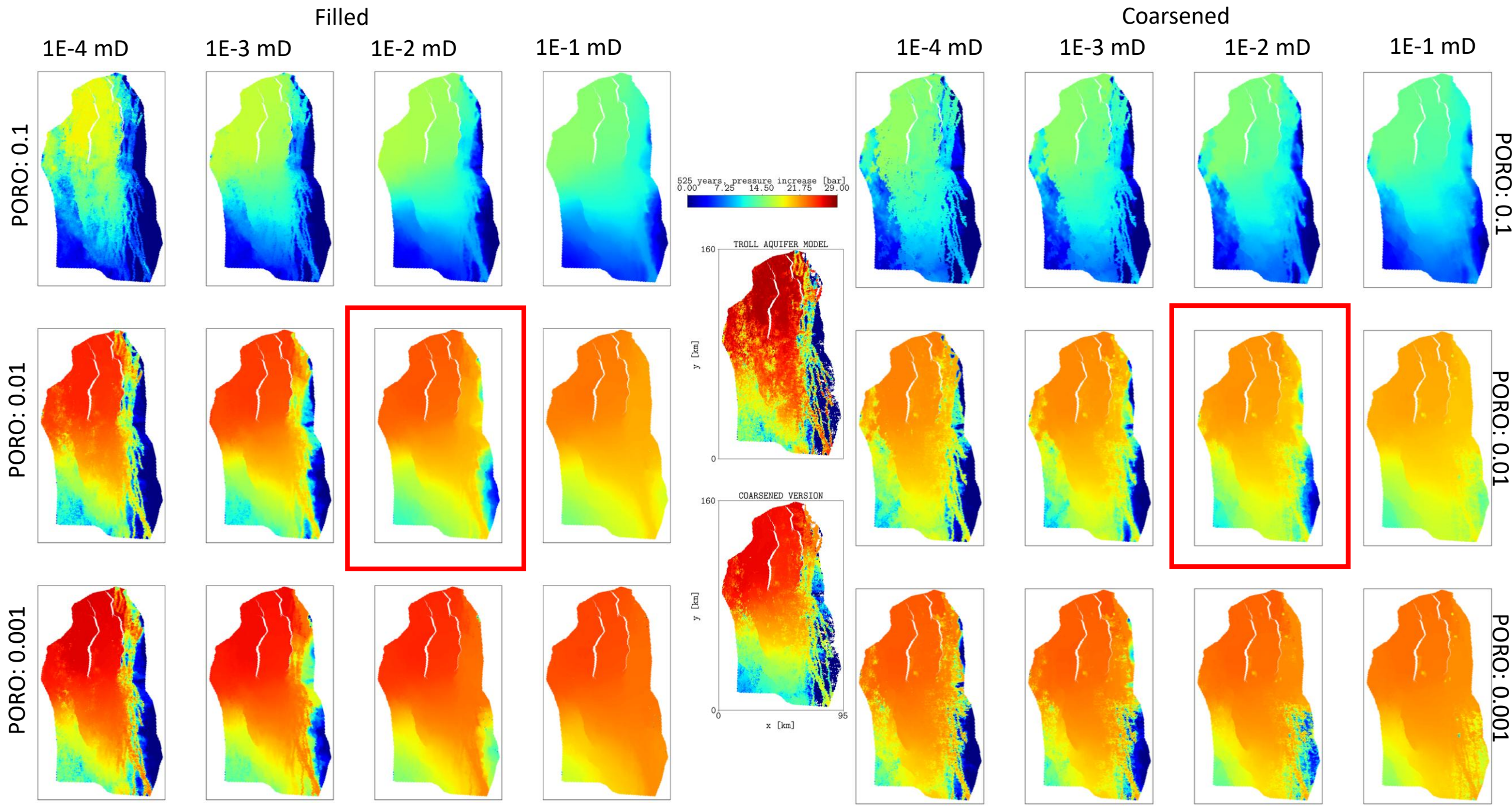
Pressure after 25 years (end of injection)



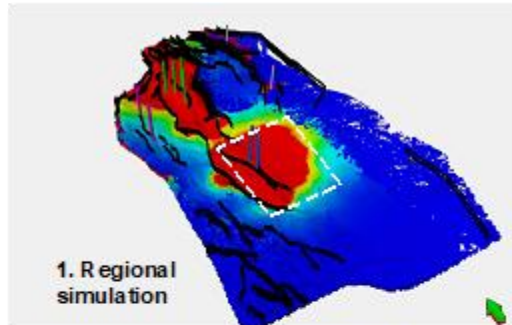
Pressure after 125 years



Pressure after 525 years

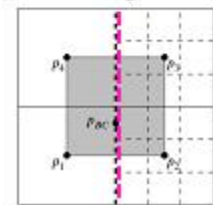


Hierarchical modeling for multi-site coupling



1. Coarse grid with an accurate representation of geology that impacts pressure

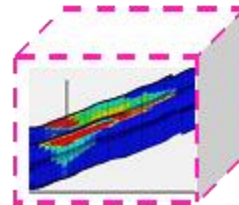
2. Map coarse pressure to fine grid



2. Export coarse-scale pressure onto fine-scale site grid

Time-dependent boundary conditions

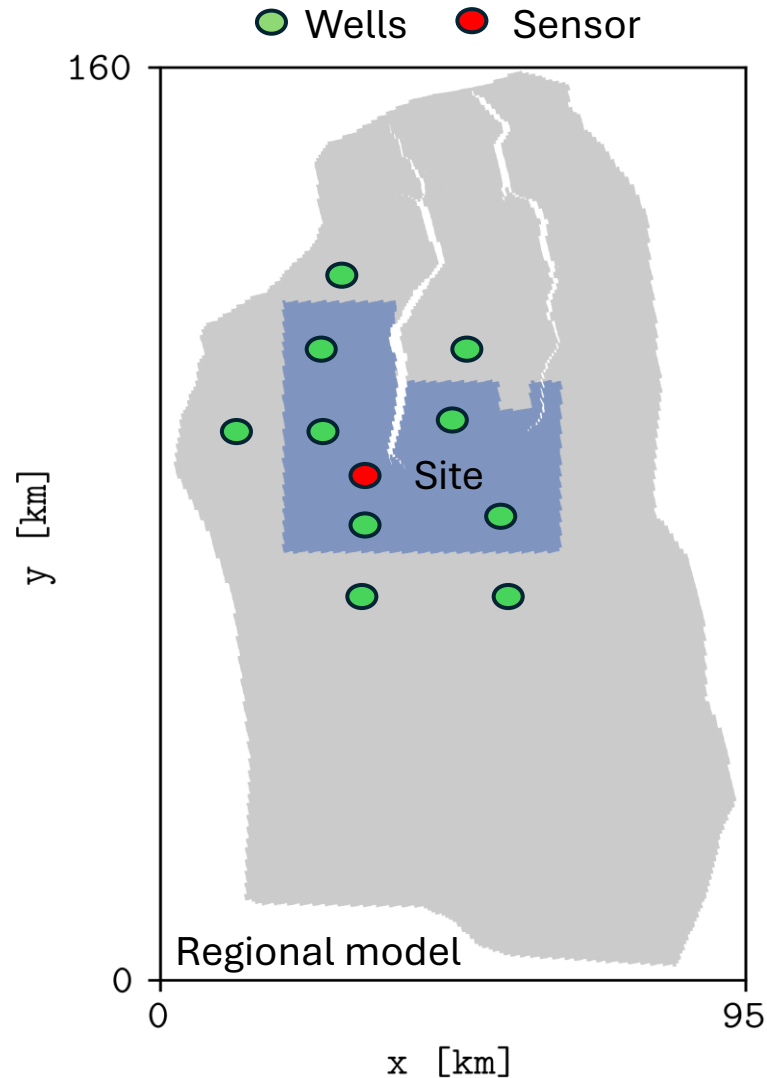
3. Site simulation



3. Fine grid with resolved physics appropriate for the local risk assessment

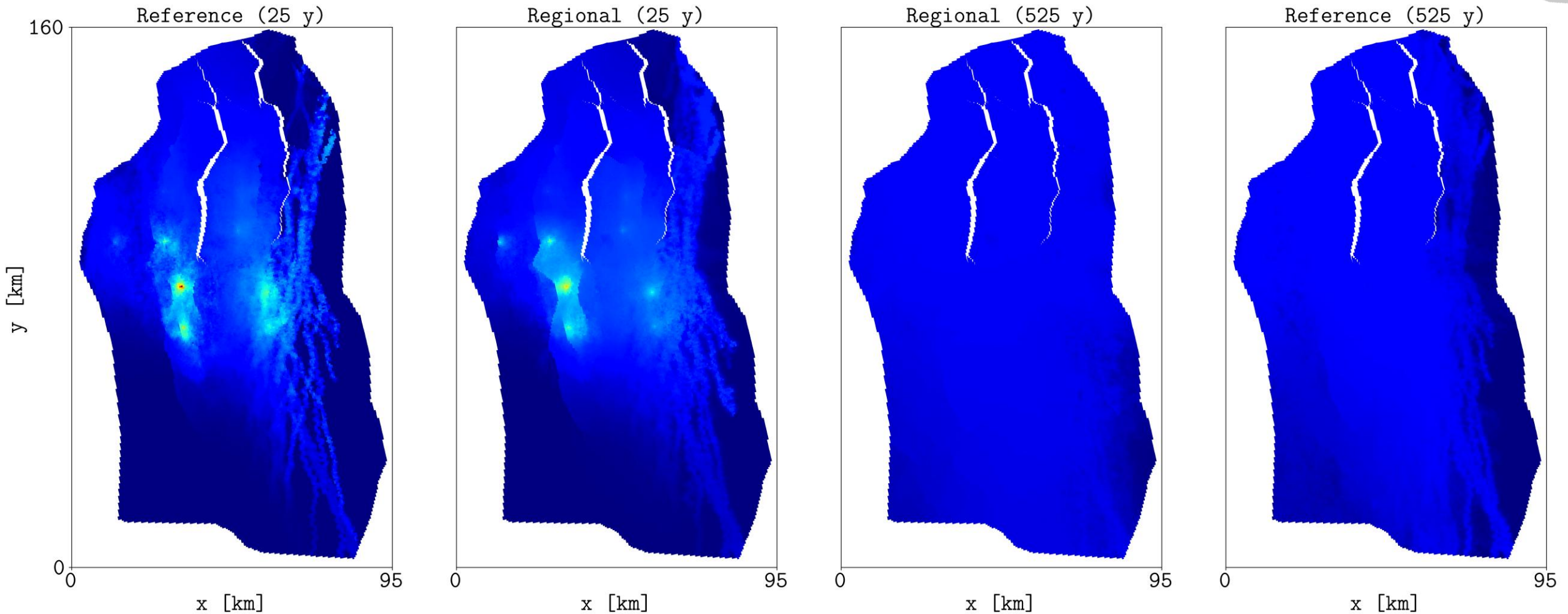
Tveit et al. "[A hierarchical approach for modeling regional pressure interference in multi-site CO₂ operations](#)", *J. Geoenergy Science and Engineering*, 248, 2025.

Hierarchical modeling for multi-site coupling

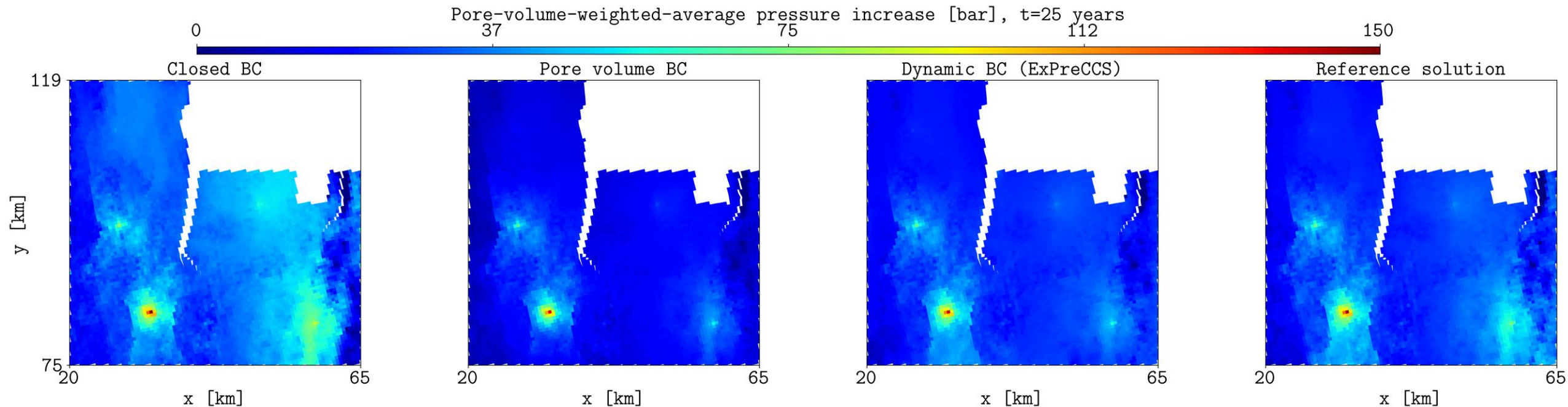


- Filled model (0.01 PORO, 1E-2 MD)
- Using the coarsened model to project the BC
- 10 wells in total, five wells inside the site
- Well locations set arbitrarily for demonstration
- Well completions along all z cells
- 25 years of injection
- Each well is injecting 1.43 Mt per year
- 500 years of monitoring
- The sensor is located on the top layer

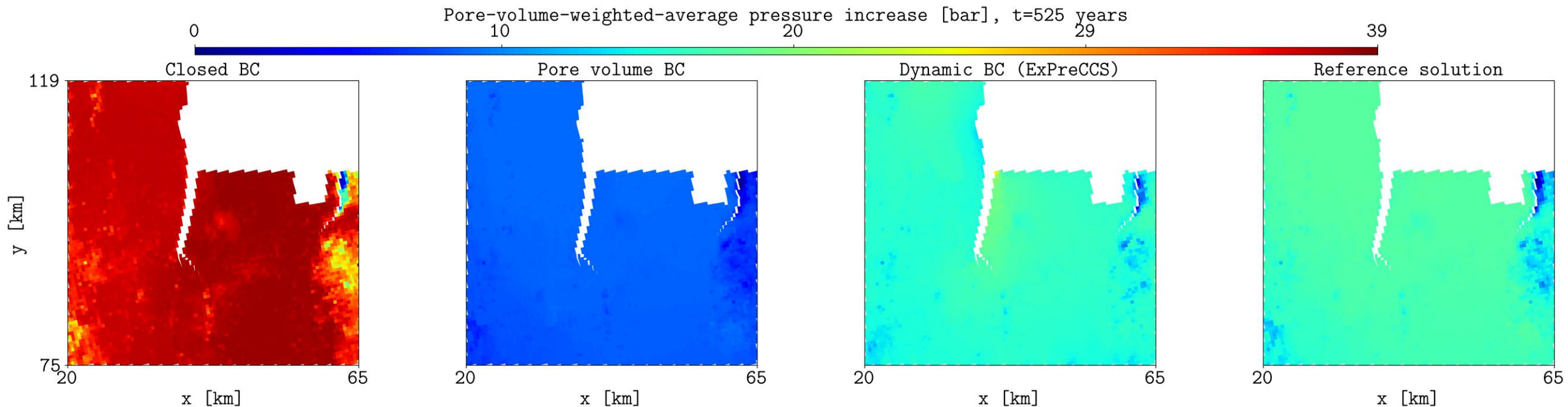
Hierarchical modeling for multi-site coupling



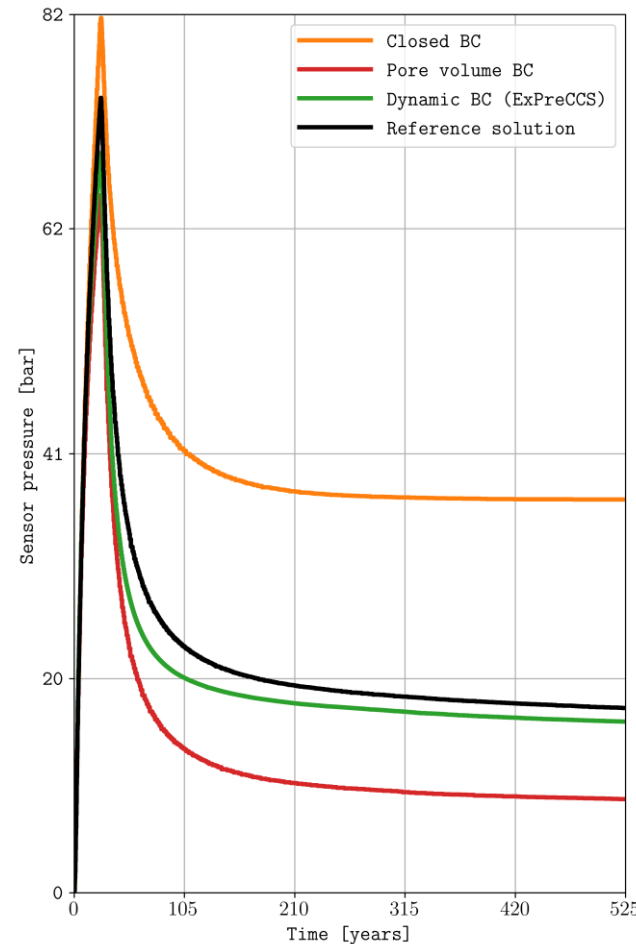
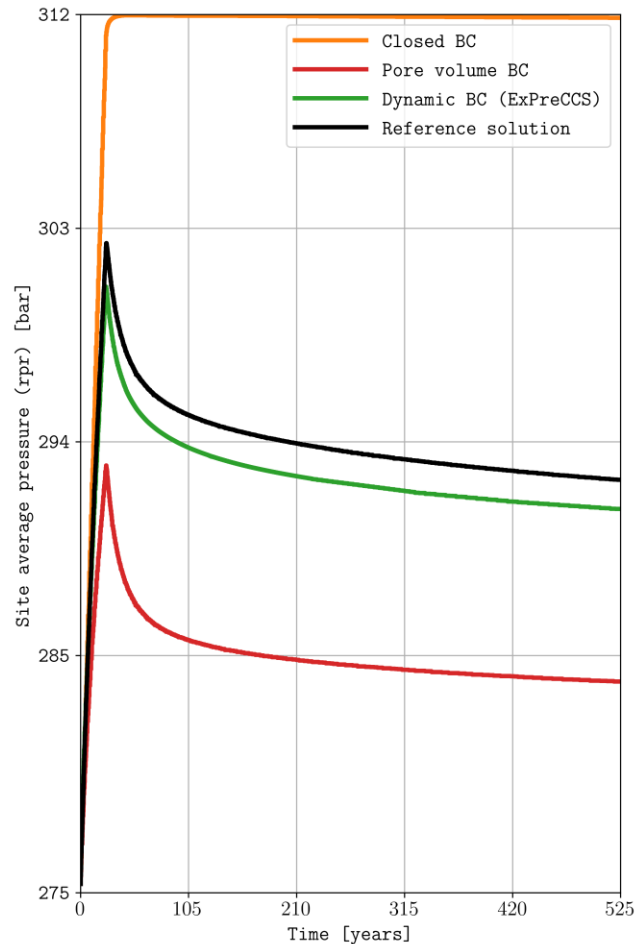
Hierarchical modeling for multi-site coupling



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Hierarchical modeling for multi-site coupling



Details on the simulations:

No. cells reference: 4,722,188

No. cells regional: 173,481

No. cells site: 820,414

Simulation time reference: 95 minutes

Simulation time regional: 30 seconds

Simulation time site: 12 minutes

Summary: regional modeling



1. The “non-net” portion of the reservoir has a significant impact on the long-term regional pressure
2. The regional model can be significantly coarser than the site model (pressure vs plume migration)
3. The hierarchical multi-site coupling approach is an efficient and simple way of coupling multi-site operations.

Acknowledgements

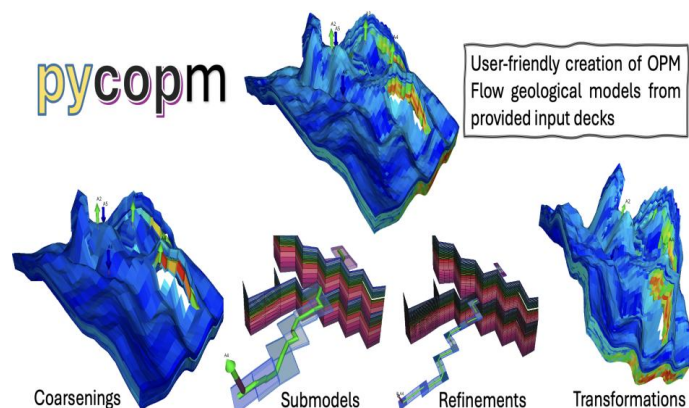


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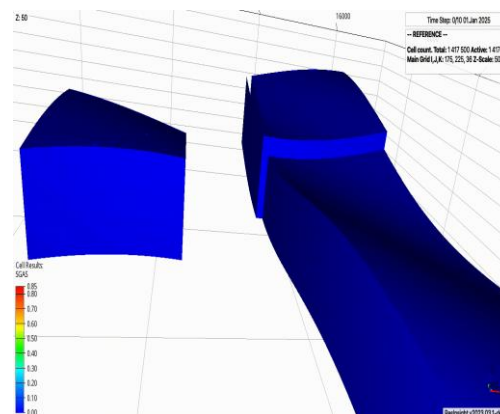


<https://github.com/OPM>

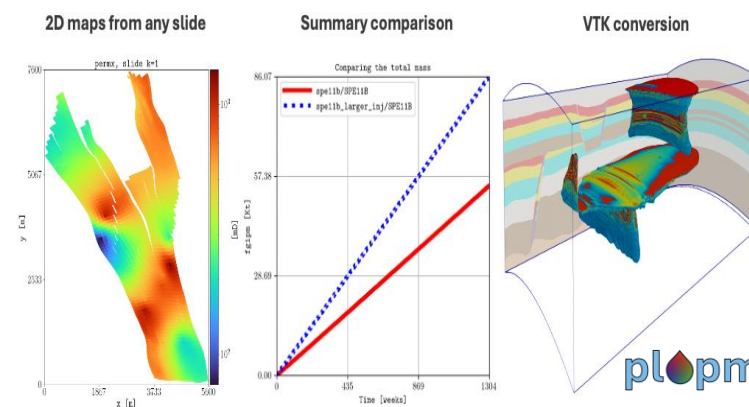
pycopm



expreccs



plop



<https://github.com/cssr-tools>



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